

The Influence of Weathering on Sinking Behavior of Microplastics

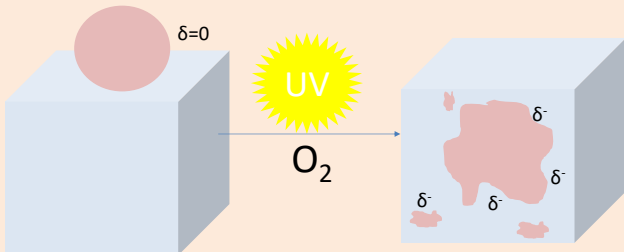
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Introduction

Current estimates project there are 150 million tons of plastic in the ocean, of which only 40 – 250 thousand tons can be found on the surface (Cozar *et al.* 2014, Eriksen *et al.* 2014), or less than 0.2%. Where is the remaining 149.8 million tons? Much of this plastic may be below the surface of the ocean, either having sunk to the bottom and reaching the sediments, or suspended/floating in the water column. To understand this better, it is necessary to understand the sinking behavior of plastics, and how weathering can change this sinking behavior.

Mechanisms

Oxidation along with mechanical stress changes the surface of microplastics, increases the surface area, hydrophilicity, and lead to fragmentation.

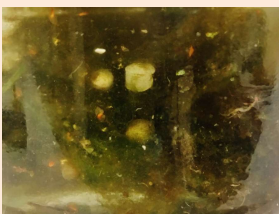


Biofilm growth increases the size and density of microplastics



Rummel *et al.* *Environ. Sci. Technol. Lett.*, 2017, 4 (7), pp 258–267

Aggregation with Biofilm (marine snow) or incorporation in organisms/feces

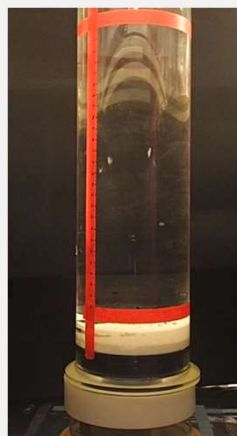


Measurement

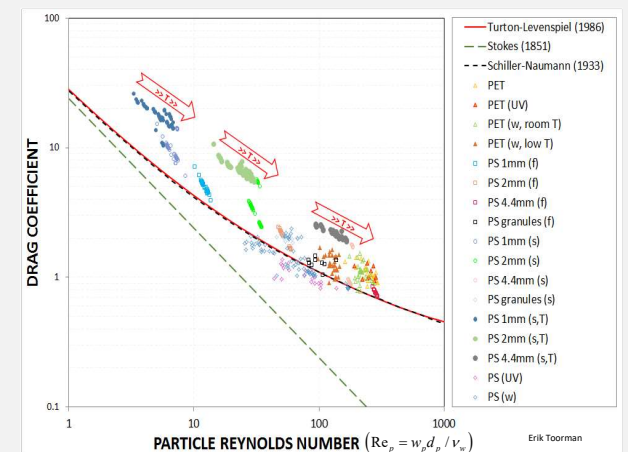
Generation of Real-World Weathered Microplastics



Column experiments to measure sinking rates for pristine vs weathered particles at different temperatures and salt concentrations.



Observations and Models of Sinking under Still Conditions



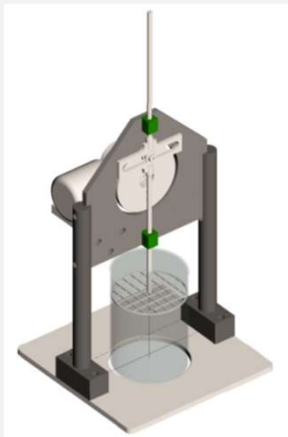
Sinking rates of different types and sizes of plastics in different sea water conditions can be plotted as a function of **drag coefficient vs particle Reynolds number** (Re_p), and compared with theoretical expectations.

1. Drag coefficient of weathered particles reasonably estimated by drag law for spheres as function of the Reynolds number
2. Amongst other factors, the Reynolds number will increase with microplastic size and density (e.g. from biofilm formation) and decrease with fragmentation (e.g. from fragmentation), or increasing viscosity in seawater (e.g. with depth)
3. «Pristine» microplastics from manufacturer deviated more from theory (higher drag coefficient = slower sinking) than weathered microplastics. The deviation was most extreme in cold, salt water. An effect of surface hydrophilicity?
4. This model can be used to generalize the effect of different seawater and microplastic particle changes with weathering on sinking under still conditions

Influence of Turbulence

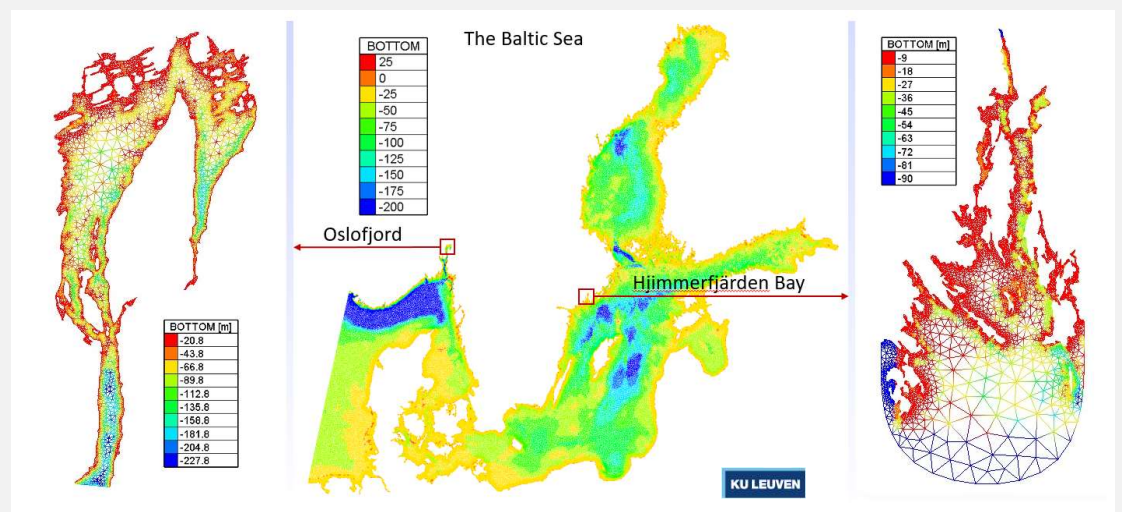
Turbulence can both prevent particles from sinking or accelerate the sinking.

$$\langle F_D \rangle = \langle c_D(\text{Re}_p) \rho_w u_{\text{rel}}^2 A_p \rangle = \rho_w A_p \langle D(\text{Re}_p) u_{\text{rel}}^2 \rangle$$



An oscillating grid was used to observe that dense microplastics < 300µm and fibers of all density remain suspended in the water column under gentle turbulence.

3-dimensional Real-World model



3D nested models are set-up in openTELEMAC.org software for Oslo Fjord (NO) and Himmerfjärden Bay (SE), with boundary data generated with a 2D depth-averaged extended Baltic Sea model. The models solve hydrodynamics (tide and wind driven currents and waves) and particle transport (including weathering, flocculation and drift).

